Cyber Partners: Harnessing Group Dynamics to Boost Motivation for More Efficient Exercise

Completed Technology Project (2013 - 2016)

Project Introduction

Original Project Aims/Objectives: The focus of the project is to use recently documented motivation gains in task groups (dyads in particular) to heighten the exercise experience for astronauts and help keep them motivated to exercise at levels necessary to mitigate reductions in aerobic fitness and muscle loss over long space missions. A secondary focus is to determine the most effective features in exercise partners for enhancing, enjoyment, confidence, and social connectedness. Specific aims: (1) Develop software to create Software Generated (SG) exercise partners and interface with exercise equipment (cycle ergometer) similar to equipment available on the International Space Station; (2) Test various design features of an SG partner within designed exercise video games to determine the most effective features for enhancing motivation to exercise, enjoyment, confidence, and connectedness; and (3) Test whether exercising with an SG partner over a 24-weeks, compared to exercising alone, leads to better aerobic capacity and muscle strength, adherence to exercise regimen, enhanced exercise enjoyment, self-efficacy, and sense of social connectedness.

Key Findings since last report: In Year 3, we continued work on Aims 2 and 3. Aim 2 was a short-term study (6 days) to determine the most effective partners to enhance exercise intensity.

In Aim 2, we tested an SG partner in one of three modes against an individual control condition: (a) coacting mode, where the subject cycled with the SG partner but whose performance was independent of the partner (i.e., they were not teammates), (b) conjunctive-teammate mode, where scores were based on the slower performer, and (c) choice mode where subject could choose coacting mode or conjunctive teammate mode for all trials. The experiment used activity routines developed by Ploutz-Snyder that consist of (a) 30 min. of continuous aerobic exercise on a cycle ergometer at or above 75% of maximum heart rate (HR max) and (b) high-intensity interval training involving 4 repetitions of 4 min. at or above 90% HR max. In Aim 2 (Year 3), we tested an additional 38 chronic exercisers (22 female). Subjects (N = 82, 47 female; M age = 44.89, 9.45) were allowed to adjust the power output (watts) during workouts. The main outcome variable was average watts cycled above target prescribed watts. Results showed no condition main effects from baseline; however, during the 4 min. interval sessions conjunctive (Mdiff = 5.23 watts) trended toward greater exercise effort than control (Mdiff = 4.45 watts) and coactive conditions (3.46 watts). The 4 min. intervals probably represent the most motivationally demanding workout at 90% HR max. Increases in effort above target watts positively correlated with Enjoyment (r = .44), Self-efficacy (r = .51), and Team perceptions (r = .21) during the 4 min. intervals. No relationships were found with less intense continuous exercise. Although this pilot study did not find significant between group increases in performance effort, participants significantly increased their effort with our exercise video game (i.e., simulated bike paths).

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In Aim 3, long-term study, we tested an SG exercise partner in one of two modes: (a) conjunctive-teammate mode and (b) conjunctive teammate who is not always superior (NAS) and is sometimes surpassed by the subject (~15% of the time), plus (c) individual control condition. We finished both cohorts of subjects (Cohort 1 = 23; 11 female; Cohort 2 = 18; 7 female). Subjects (N = 41; M age = 45.53 8.12) exercised 6 days/week for 24 weeks, using the following aerobic routines developed by Ploutz-Snyder: (a) 30 min. of continuous aerobic exercise on a stationary cycle at or above 75% HR max, (b) 4x4 min. intervals at or above 90% HR max with 3 min. active rest, (c) 6x2 min. intervals at varying intensities with 2 min. active rest, and (d) 30 sec. sprint intervals at maximal effort with 20 sec. active rest. We first tested whether the Conjunctive or NAS groups adhered more to the protocol than Controls. Conjunctive (M = 122.67) and NAS (M = 123.69) conditions averaged 15 more days completing the protocol than the Control (M = 107.00). However, group differences were not statistically different. In terms of our primary dependent measure, effort (watt increases above one's target), analyses are based on the continuous and 4-min. interval sessions. Subjects were not allowed to increase their intensity on the 2-min. intervals. Similarly, the dependent measure for the 30 sec. sprints was number of intervals completed, which all subjects completed. During Week 20 (last week with >80% of subjects remaining), NAS subjects increased their effort more (M = 8.9 watts) compared to Controls (M = 1.5 watts; d = 0.37) and Conjunctive subjects (M = 3.9 watts) on the 4-min. interval workout. Throughout the duration of the study, NAS subjects always outperformed Controls on the 4-min. intervals. All groups had large significant increases in VO2max from baseline (M = 34) to midpoint (M = 39), then values leveled off from midpoint to final (M = 38). Social connectedness rose significantly from midpoint (M = 2.96) to final (M = 3.48), and those with an SG partner increased their teams' perceptions from midpoint (M = 3.39) to final (M = 4.22). Subjects in NAS (M = 7.85) and Conjunctive conditions (M = 7.26) had higher self-efficacy beliefs than Controls (M = 6.86 2.83) after 1 week with the SG partner. Enjoyment remained stable, above response scale midpoint, across 24 weeks.

Impact of Key Findings: Aim 3: The findings in Aim 3 suggest that having an SG partner, where the subject can intermittently be superior (~15% of time in NAS condition) is most motivating in the most demanding 4-min interval workouts.

Proposed Research Plan for Coming Year: We will prepare manuscripts to submit to journals and present results at professional conferences.

Anticipated Benefits

Exercising for purely personal concerns (for improving health, losing weight, physical rehabilitation, etc.) can be a powerful motivator to continue exercise and to exercise at intensity levels high enough to realize greater health

Organizational Responsibility

Responsible Mission Directorate:

Space Operations Mission Directorate (SOMD)

Lead Organization:

National Space Biomedical Research Institute (NSBRI)

Responsible Program:

Human Spaceflight Capabilities

Project Management

Program Director:

David K Baumann

Principal Investigator:

Deborah L Feltz

Co-Investigators:

Brian Winn
Norbert Kerr
James Pivarnik
Lori L Ploutz-snyder

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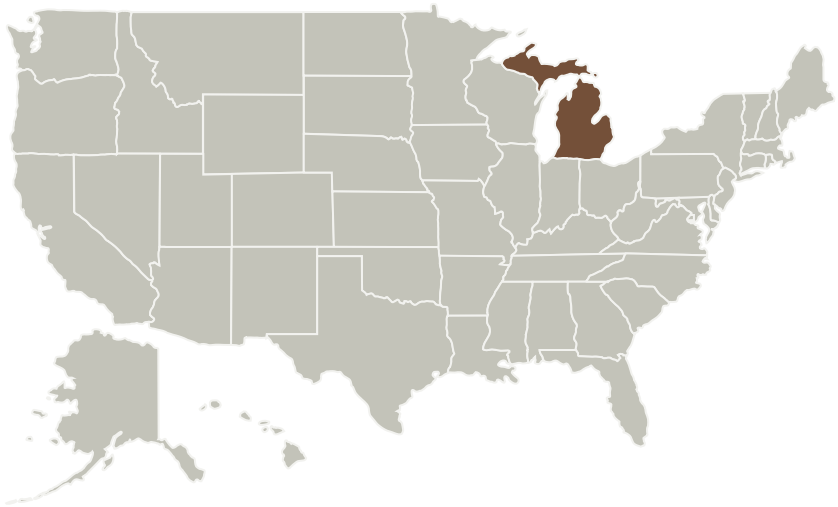
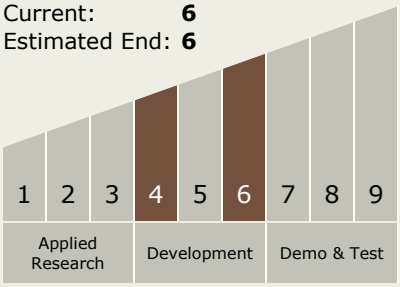
benefits, but interpersonal and social concerns (for comparing favorably with others or for not letting a partner down) have the potential to add equally powerful new sources of motivation. These sources of motivation could open up a powerful set of new tools in exercise video game design for fitness especially for those with social physique anxiety, those who lack the time and/or resources to join an exercise group, and those in exercise rehabilitation therapies. Although current commercial exercise video games have been shown to have some health benefit in terms of increased caloric expenditure and cardiorespiratory endurance, few games have been based on theoretical knowledge of exercise motivation. Moreover, none of the extant exercise games (e.g., Wii Fit, PS-2's EyeToy: Kinetic) incorporate the critical design features suggested by contemporary social psychological research, particularly research on motivation gains in task groups (viz., immediate feedback on performance of one or more other players, the ability to control the discrepancy in abilities of players, and most importantly, the indispensability of individual player effort for determining team outcomes). Thus, our research has the potential for Earth-based commercial applications to build more engaging and enjoyable exercise video games for various populations.

Primary U.S. Work Locations and Key Partners



Technology Maturity (TRL)

Start: **4**
Current: **6**
Estimated End: **6**



Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  - TX06.3 Human Health and Performance
    - TX06.3.3 Behavioral Health and Performance

Target Destinations

The Moon, Mars

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Organizations Performing Work	Role	Type	Location
National Space Biomedical Research Institute(NSBRI)	Lead Organization	Industry	Houston, Texas
Michigan State University	Supporting Organization	Academia	East Lansing, Michigan
Universities Space Research Association(USRA)	Supporting Organization	R&D Center	Huntsville, Alabama

Primary U.S. Work Locations
Michigan

Project Transitions

June 2013: Project Start

July 2016: Closed out

Closeout Summary: The major emphasis in Year 3 was to complete our 24-week study (Aim 3). We have now collected a nd analyzed data on both cohorts of subjects (N = 41; 18 female). The first cohort included 11 women, 12 men (M age = 4 6.74; ± = 6.98). The second cohort included 7 women, 11 men (M age = 44.17; 9.31). We strived for equal numbers of m ales and females, but in any case, insured proportional numbers of males and females in each condition. Subjects were simi lar in age (M = 45.53 8.12) and aerobic fitness (M = 33.77 6.15) to experienced astronauts. Subjects in Cohort 1 finished t heir training program in June 2015. Cohort 2 started between August and November, 2015 and finished between February and May, 2016. Baseline, midpoint, and post-test fitness data have been collected and analyzed as well as measures of enj oyment, self-efficacy, social connectedness, and perceived team perceptions. We began our long-term study (Aim 3) before finishing our short-term, 6-day study (Aim 2) in order to stay on schedule. In Year 3, also we finished Study 1 (Aim 2) to pr ovide a larger sample comparing the 30 min. continuous cycling (at 75% VO2 max) and high-intensity interval cycling invol ving 4 repetitions of 4 min. (at 90% VO2 max) under SG partner/no partner conditions. We tested an additional 38 chronic exercisers (22 female). Total subjects were 86 (47 female; M age = 44.89, 9.45). We have presented our preliminary findin gs for both studies at regional, national, and international conferences. We have begun drafting manuscripts to submit to v arious research journals and conducting more fine-grained analyses.

Stories

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/64545)

Abstracts for Journals and Proceedings
(https://techport.nasa.gov/file/64526)

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Project Website:

https://taskbook.nasaprs.com